8. Pinniped research at Cape Shirreff, Livingston Island, Antarctica, 2000-2001; submitted by Michael E. Goebel, Brian W. Parker, Alison R. Banks, Daniel P. Costa, Benjamin Pister and Rennie S. Holt.

8.1 Objectives: Pinniped research was conducted by the U.S. AMLR Program at Cape Shirreff, Livingston Island, Antarctica (62°28'S, 60 °46'W) during the 2000/2001 season. Studies on the diving and foraging ecology of adult female fur seals were also conducted in collaboration with the University of California-Santa Cruz. A four-person field team arrived at Cape Shirreff via the R/V *Lawrence M. Gould* on 16 November 2000. Research activities were initiated soon after and continued until closure of the camp on 28 February 2001. Our research objectives for the 2000/01field season were to:

A. Monitor Antarctic fur seal female attendance behavior (time at sea foraging and time ashore attending a pup);

B. Assist Chilean researchers in collecting length, girth, and mass for fur seal pups every two weeks throughout the season;

C. Document fur seal pup production at designated rookeries on Cape Shirreff and assist Chilean colleagues in censuses of fur seal pups for the entire Cape and the San Telmo Islands;

D. Collect fur seal scats weekly for diet studies;

E. Collect a milk sample from each adult female fur seal captured for fatty acid signature analysis and diet studies;

F. Deploy time-depth recorders on adult female fur seals for diving studies;

G. Record at-sea foraging locations for adult female fur seals using ARGOS satellite-linked transmitters (deployments to coincide with the US-AMLR Oceanographic Survey cruises);

H. Tag fur seal pups for future demographic studies;

I. Extract a lower post-canine tooth from adult female fur seals for aging studies; and

J. Deploy a weather station for continuous recording of wind speed, wind direction, ambient temperature, humidity and barometric pressure during the study period.

8.2 Accomplishments:

A. Female Fur Seal Attendance Behavior: Sometime after parturition, Otariid females begin a cyclical series of trips to sea and visits to shore to suckle their offspring. These cycles are called attendance behavior. Measuring changes in attendance patterns (especially the duration of trips to sea) of lactating Otariids is one of the standard indicators of a change in the foraging environment. We instrumented 29 lactating females from 5-12 December 2000. The study was conducted according to CCAMLR protocol (CCAMLR Standard Method C1.2 Procedure A) using VHF radio transmitters (Advanced Telemetry Systems, Inc., Model 7PN with a pulse rate of 40ppm). Presence or absence on shore was monitored for each female every 30 minutes for 30 seconds. All females were instrumented 1-2 days post-partum (determined by the presence of a newborn with an umbilicus) and were left undisturbed for at least their first six trips to sea. Pups were captured at the same time as their mothers, and weighed, measured, and marked with an identifying bleach mark. The general health and condition of the pups were monitored throughout the study by making daily visual observations. Of the 29 mother-pup pairs, one pup died shortly after birth and we report results for the remaining 28. The presence/absence onshore was recorded for each female for the first six trips to sea.

The first female in our study to begin her foraging cycles did so on 10 December and last female to complete six trips to sea did so on 26 January. The mean trip duration for the combined first six trips to sea this year was lowest since data collection began at Cape Shirreff in 1997/98 (Table 8.1, Figure 8.1; ANOVA, $df_{3,667}$, $p<0.005$). Visit durations were also longer in 1999/00 and 2000/01 than in the first two years but were no different from each other (Table 8.1, Figure 8.1; ANOVA, $df_{3,667}$, $p<0.005$). In three out of the four years (1998/99-2000/01), the distribution of trip durations was skewed to longer trips (Table 8.1, Figure 8.2). Visit durations for all four years were likewise skewed (Table 8.1).

There was no difference in the postpartum mass of our attendance females from 1998/99 to 2000/01. Females in those three years were, however, larger than females in 1997/98 (Figure 8.3a; ANOVA, $df_{3,115}$, $p<0.0001$; **97/98:** Mean=39.2 kg ±5.76, N=31; **98/99:** Mean=45.6 kg ±6.67, N=32; **99/00:** Mean=46.5 kg ±5.90, N=23; **00/01:** Mean=46.3 kg ±4.52, N=28). This is because females in that year were sampled later (21-31 December) and late arriving females tend to be younger and smaller. The mass-to-length ratio for all three years was not different (Figure 8.3b; ANOVA, $df_{3,115}$, $p=0.62$; **97/98:** Mean=0.338 ±0.033, N=31; **98/99:** Mean=0.347 ±0.041, N=32; **99/00:** Mean=0.346 ±0.034, N=23; **00/01:** Mean=0.35 kg ±0.026, N=28).

B. Fur Seal Pup Growth: Measures of fur seal pup growth were a collaborative effort between the US research team and Chilean researchers. Data on pup weights and measures were collected every two weeks beginning on 16 December and ending 14 February (five bi-weekly samples). Data were collected as directed in CCAMLR Standard Method C2.2 Procedure B. The results will be submitted to CCAMLR by Chilean researchers.

C. Fur Seal Pup Production: Fur seal pups (live and dead) and females were counted by US researchers at four main breeding beaches (Copihue, Maderas, Cachorros, and Chungungo) on the east side of the Cape. Censuses were conducted every other day from 18 November 2000 through 10 January 2001. The maximum number counted at the combined four beaches in 2000/01 was 2,248 on 29 December 2000 (Figure 8.4), a 6.8%

increase over the maximum count for the same sites in 1999/00 (2,104 on 3 January 2000). The median date of pup births was 8 December, the same day as last year but two days earlier than in 1997/98 and 1998/99.

D. Diet Studies: Information on fur seal diet was collected using three different sampling methods: collection of scats, enemas, and fatty acid signature analysis of milk. In addition to scats and enemas, an occasional regurgitation is found in female suckling areas. Regurgitations often provide whole prey that is only minimally digested. Scats are collected from around suckling sites of females or from captured animals that defecate while captive. All females that are captured to remove a time-depth recorder or satellite-linked transmitter (PTT) are given an enema to collect fecal material. Ten scats were collected from female suckling sites every week beginning 20 December. In total, we collected and processed 104 scats and enemas from 20 December 2000-23 February 2001. Diet samples that cannot be processed within 24 hours of collection were frozen. All samples were processed by 26 February. Up to 30 krill carapaces were measured from each sample that contained krill. Otoliths were sorted, dried, identified to species and measured for length and width. The number of squid beaks was counted and preserved in 70% alcohol for later identification. Results indicated an increasing proportion of fish in the diet from December through February; however, all scats collected through the season had at least some krill (Figure 8.5). Squid occurred only in a few scats (2) in February (Figure 8.5, Table 8.2). Compared to our results from last year, there was more krill and less fish in the diet this year (Table 8.2, X^2=20.8, d.f.=4, p<0.0005).

The length and width of krill carapaces found in fur seal scats were measured to determine length distribution of krill consumed. Up to thirty carapaces from each scat were randomly selected and measured according to Hill (1990). The following linear discriminant function (Reid and Measures, 1998) was applied to the carapace length (CL) and width (CW) to determine sex of individual krill:

$$D = -1.04 - 0.146(CL) + 0.265(CW)$$

Positive discriminant function values were identified as female and negative values male. Once the sex for each krill was determined the following regression equations from Reid and Measures (1998) were applied to calculate total length (TL) from the carapace length:

$$\text{Females: } TL = 15.3 + 2.09(CL)$$
$$\text{Males: } TL = 13.9 + 2.29(CL)$$

A total of 2,941 carapaces was measured from 104 scats in 2000/01. Summary statistics are presented in Table 8.3. Data from 1999/00 are also presented for comparison. Krill consumed by fur seals in 2000/01 were on average larger than in 1999/00 (Table 8.3; ANOVA, d.f.$_{1,5465}$, F-ratio = 833.3, p<0.0005). The length distributions for both years in 2mm increments are presented in Figure 8.6.

E. Fatty Acid Signature Analysis of Milk: In addition to scats, enemas, and regurgitations, we collected 116 milk samples from 69 female fur seals. Each time a female was captured (either to instrument or to remove instruments), ≤30ml of milk was collected by manual expression. Prior to collection of the milk sample, an intra-muscular injection of oxytocin (0.25ml, 10 UI/ml) was administered. Milk was taken (within several hours) to the lab where two 0.25ml aliquots were collected and stored in a solvent-rinsed glass tube with 2ml of Chloroform with 0.01% butylated hydroxytoluene (BHT, an antioxidant). Samples were flushed with nitrogen, sealed, and stored frozen for later extraction of lipid and trans-esterification of fatty acids. Of the 116 samples, 27 were collected from perinatal females and 34 were collected from 26 females for which we had dive data for the foraging trip prior to milk collection.

F. Diving Studies: Twelve of our 28 females transmittered for attendance studies also received a time-depth recorder (TDR, Wildlife Computers Inc., Mark 7, 8.6 x 1.9 x 1.1cm, 27g) on their first visit to shore. All of them carried their TDR for at least the first six trips to sea. In addition, all other females captured for studies of at-sea foraging locations also received a TDR. The total number of females with diving data for 2000/01 was 28. The total number of trips recorded on TDRs from 10 December 2000- 17 February 2001 was 125.

G. Adult Female Foraging Locations: We instrumented 25 females with satellite-linked transmitters (ARGOS-linked PTT's) from 23 December- 17 February. Twenty of these were deployed to coincide with the US-AMLR large-scale oceanographic survey. Of the 25, nine carried a PTT for a single trip to sea, two for two trips to sea, thirteen others for three trips and one female carried her PTT for four trips. Results of fur seal foraging location data analysis and comparisons to the two previous seasons are pending.

H. Demography and Tagging: Together Chilean and U.S. researchers tagged 499 fur seal pups (266 females, 232 males, 1 unknown sex) from 20 January- 27 February 2001. All tags placed at Cape Shirreff were Dalton Jumbo Roto tags with white tops and orange bottoms. Each pup was tagged on both fore-flippers with identical numbers (2001-2294, 2296-2500). Most pups were tagged on 31 January and 14 February and most (449) on the east side of the Cape from Playa Marko to Chungungo beach. Fifty tags were put on pups at Loberia on the northwest side of the Cape.

In addition to the 499 pups tagged, we also tagged 35 adult lactating, previously untagged, females (188-221,230). All tags were placed on females with parturition sites on east-side beaches (Copihue, Maderas, Cachorros, and Chungungo beaches).

Last year we added 100 adult females to our tagged population. Of the 100 tags added, four were placed at Loberia (outside our study area) and one was a re-tagged female (011), leaving 95 new tags to add to those already tagged. These 95, when added to the females that returned in the previous season (n=78), gave an expected known tagged population of 173 for 2000/01 (Table 8.4). Of these, 156 (90.4%) returned in 2000/01 to Cape Shirreff and 136 (87.2%) returned pregnant (Figure 8.7). The return rate was higher in 2000/01 than in 1998/99 but lower than last year; natality was lower than in the two previous years (87.2% vs. 90.3% in 1998/99 and 92.3% in 1999/00; Figure 8.7).

Our tagged population of females returned (on average) one day earlier than last year. In 1999/00, the mean date of pupping for tagged females (which had a pup in both years) was 9 December (±7.5, N=94) and in 2000/01, for the same females, it was 8 December (±7.7, N=94). The median date of pupping for our tagged females for both years was one day earlier (1999/00: 8 December, 2000/01: 7 December). This result is one day earlier for both years than our estimates of the median date of pupping based upon pup counts for the season (see section C above).

We observed 26 yearlings (11 females, 15 males that were tagged as pups in 1999/00; Table 8.5) in 2000/01. This is more tagged yearlings than we sighted last season. Table 8.5 presents observed tag returns for three cohorts in their first year. Tag deployment and re-sighting effort for all three cohorts were similar and differences are likely due to changes in the post-weaning physical and/or biological environment. The differences in return rates are not necessarily due to survival but may be due to other factors (e.g. physical oceanography of the region, over-winter prey availability or other factors) that influence whether animals return to natal rookeries in their first year.

We calculated the minimum percent survival based upon tag re-sights for the first two years following tagging (Table 8.6). The survival values are adjusted based upon the probability that an individual would lose both tags. Tag loss (right or left) was assumed to be independent. The results presented are for the minimum percent survival because animals return for the first time to natal rookeries at different ages and the probability of returning at age 1, age 2, *et cetera* may vary for different cohorts. Most notable, given similar re-sighting effort the two cohorts presented have return rates in the first two years that are very different. This difference is important whether due to survival or differences in dispersal that result in different rate of return.

I. Tooth Extraction and Age Determination: We began an effort of tooth extraction from adult female fur seals for age determination in 1999/00. Tooth extractions are made using gas anesthesia (isoflurane, 2.5-5.0%), oxygen (4-10 liters/min), and midazolam hydrochloride (1cc). A detailed description of the procedure was presented in the 1999/00 annual report.

This year, from 17 January through 1 February, we took a single post-canine tooth from 60 previously tagged females. Two of these were from 3-year old nulliparous females tagged as pups and one was from a female that was tagged as a pup at Seal Island. The teeth collected from these three females will be used for validation of the aging technique. Females ranged in size from a mass of 25.0-56.5kg and length of 117-150cm. The mean total time captive was 18.0 min (±6.0) and the mean total time under anesthesia was 14.0 min (± 3.0, n=60). The time captive and the time under anesthesia both increased over last year (12.6 and 9.6 min, respectively) due to fewer personnel assisting (five in 1999/00 vs. three in 2000/01).

Tooth extraction is the most invasive of our research techniques and could potentially affect reproductive success. We therefore have focused some effort to measure the effects of extracting a tooth on attendance behavior (i.e. trip and visit durations), diving behavior, and return and natality rate in the year following tooth extraction.

Last year we extracted a tooth from 79 of our 173 tagged females expected to arrive this year. We compared return and natality of those 79 females to the remaining 94 females, treated as a control group because they were not captured for a tooth extraction last year (Figure 8.8). Females that had a tooth extracted in 1999/00 had a slightly lower rate of return (0.5% lower) and natality (2.3% lower) in 2000/01 than did females that did not have a tooth extracted (Percent return: 90.4 vs. 89.9; Natality: 88.2 vs. 85.9%). The differences were not significant however (Return: X2=0.015, d.f.=1, P=0.90; Natality: X2=0.186, d.f.=1, P=0.67).

Eleven females in our sample carried VHF radio transmitters before and after tooth extraction. Arrival and departures were recorded with a remote VHF receiver and a data-logging device that recorded and stored presence or absence ashore every 15 minutes. The durations of the visit preceding, the visit following and the visit of tooth extraction were compared using analysis of variance (ANOVA). Likewise, the trip duration for the trip before the tooth extraction visit and for the two subsequent trips were compared. There was a difference in visit durations but no difference was found in trip durations (Figure 8.9). The difference in visits was due to the tooth extraction visit being on average about 0.5 day (d) longer (**Preceding visit:** 1.6d ±0.5, **Tooth extraction visit:** 2.0d ±0.6, **Following visit:** 1.5d ±0.5; $F_{2,30}$=3.79, P=0.034). Trip durations were on average 3.1d ±0.8 (**Preceding trip:** 3.0d ±0.6, **Following trip:** 3.0d ±0.9, **Following 2nd trip:** 3.2d ±1.0; $F_{2,30}$=0.27, P=0.767). Age determination of the teeth collected this year is currently underway.

J. Weather at Cape Shirreff: A weather data recorder (Davis Weather Monitor II) was set up at the US-AMLR field camp at Cape Shirreff from 16 November 2000 to 26 February 2001. The recorder archived wind speed and direction, barometric pressure, temperature, humidity, and rainfall at 15-minute intervals. The sampling rate for wind speed, temperature, and humidity was every eight seconds; the averaged value for each 15-minute interval was stored in memory. Barometric pressure was measured once at each 15-minute interval and stored. When wind speed was greater than 0, the wind direction for each 8-second interval was stored in one of 16 bins corresponding to the 16 compass points. At the end of the 15-minute archive interval, the most frequent wind direction was stored in memory.

Mean daily temperature at Cape Shirreff was (on average) 0.5°C cooler this year than in 1999/00 for the same time period (4 December-24 February). Total measurable precipitation in 2000/01 was similar to 1999/00 with similar total number of days of measurable precipitation for the time period 21 December-24 February (**1998/99:** 59.6mm for 43 days, **1999/00:** 57.1mm for 35 days, 2000/01: 56.0mm for 36 days). Over-winter snow cover at the start of this season was similar to last year though we do not have a precise measure of this. By the time fur seal pupping began in late November most snow had melted from breeding areas. The lighter snow cover and decreased precipitation over 1998/99 resulted in a relatively dry season similar to last year.

8.3 Preliminary Conclusions: The 2000/01 season was better for Antarctic fur seals by several measures than the previous three seasons. Fur seal pup production at US-AMLR study beaches on Cape Shirreff increased by 6.8% over last year. The median date of pupping based on pup counts was two days earlier than in 1997/98 and 1998/99. The mean arrival and parturition dates for our tagged female population was also two days earlier than those years but the same as last year. Though return rates for adult females were slightly lower than the previous year, at 90.2% over-winter survival is still high and there was no change in arrival condition compared to last year. Return rate for yearlings was higher this year than last. Adult female trip duration for the first six trips to sea was significantly less than in previous years indicating improved foraging conditions. Fur seals this year had slightly more krill in the diet than last year and though the overall percent of fish in the diet was lower, the trend for an increasing percent occurrence of fish and squid as the season progresses was present as in previous years. The mean length of krill in fur seal diet increased this year over last year, reflecting the same results as found in at-sea surveys from our oceanographic survey vessel. Our preliminary studies of the effect of tooth extraction on survival, natality, and attendance behavior indicate that if there are any measurable significant differences, they are minimal.

8.4 Acknowledgements: We are grateful to our Chilean colleagues: Layla Osman, Jorge Acevedo, Romeo Vargas, Olivia Blank, and Rodrigo Hueke-Gaete for their assistance in the field, good humor and for sharing their considerable knowledge and experience of Cape Shirreff. Some of the tag re-sight data used in this report were provided by our Chilean colleagues. Thanks to Benjamin Pister, Michael Taft, Iris Saxer, and Wayne Trivelpiece for their help with pinniped studies and to the captain and crew of the L.M. Gould who provided transport and assistance to the Cape Shirreff opening team. We are, likewise, grateful to the AMLR personnel and the Russian crew of the R/V *Yuzhmorgeologiya* for their invaluable support and assistance to the land-based AMLR personnel. Studies on the foraging ecology and energetics of fur seals were supported by National Science Foundation Grant #OPP 9726567 to Daniel P. Costa and Michael E. Goebel.

8.5 References:

Hill, H.J. 1990. A new method for the measurement of Antarctic krill *Euphausia superba* Dana from predator food samples. *Polar Biology* 10(4): 317-320.

Reid, K., and Measures, J. 1998. Determining the sex of Antarctic krill *Euphausia superba* using carapace measurements. *Polar Biology* 19(2): 145-147.

Table 8.1. Summary statistics for the first six trips and visits (non-perinatal) for female Antarctic fur seals rearing pups at Cape Shirreff, Livingston Island, 1997/98 – 2000/01.

Year	N	Range	Median	Mean	St.Dev.	Skew[1]	SE Skew	Significance	(+/-)
Trip Durations:									
1997/98	180	0.50-9.08	4.07	4.19	1.352	0.083	0.181	0.459	-
1998/99	186	0.48-11.59	4.23	4.65	1.823	0.850	0.178	4.775	+
1999/00	138	0.60-8.25	3.25	3.47	0.997	1.245	0.206	6.044	+
2000/01	168	0.75-5.66	2.69	2.71	0.828	0.874	0.187	4.674	+
Visit Durations:									
1997/98	179	0.46-2.68	1.25	1.35	0.462	0.609	0.182	3.346	+
1998/99	186	0.21-3.49	1.27	1.33	0.535	0.947	0.178	5.320	+
1999/00	138	0.10-4.25	1.51	1.72	0.635	1.088	0.206	5.282	+
2000/01	168	0.44-3.15	1.52	1.68	0.525	0.485	0.187	2.594	+

[1]Skewness: A measure of asymmetry of the distribution of the data. A significant positive value indicates a long right tail. Significance is indicated when the absolute value of Skewness/Standard Error of Skewness (SE) is greater than two.

Table 8.2. Results of a contingency table on the proportions of major prey types (krill, fish, and cephalopods) in Antarctic fur seal scats and enemas collected at Cape Shirreff, Livingston Island in three years, 1998/99 through 2000/01. X^2=20.8, d.f.=4, P<0.0005.

	1998/99		1999/00		2000/01	
Prey	**Observed**	**Expected**	**Observed**	**Expected**	**Observed**	**Expected**
Krill	84	79.3	94	113.0	104	89.9
Fish	32	39.9	71	56.8	39	45.3
Squid	12	8.7	17	12.4	2	9.9

Table 8.3. Krill length (mm) in fur seal diet for 1999/00 and 2000/01.

	1999/00: All Krill	Female	Male	2000/01: All Krill	Females	Males
N:	2528	1623	905	2941	1578	1363
Median (mm):	50.8	52.9	48.3	52.9	52.9	52.8
Mean (mm):	50.6	52.0	47.9	53.1	53.6	52.5
St.Dev.:	4.462	3.314	5.005	3.824	3.567	4.017
Maximum:	59.7	59.2	59.7	39.1	40.4	39.1
Minimum:	13.9	40.4	13.9	64.3	63.4	64.3
Sex Ratio:	1:1.8			1:1.2		

Table 8.4. Tag returns and pregnancy rates for adult female fur seals at Cape Shirreff, Livingston Island, 1998/99 – 2000/01.

Year	Known Tagged Population[1]	Returned	Pregnant	% Return	% Pregnant	Tags Placed
1997/98						37[2]
1998/99	37	31	28	83.8	90.3	52
1999/00	83	78	72	94.0	92.3	100
2000/01	173	156	136	90.4	87.2	35

[1]Females tagged and present on Cape Shirreff beaches the previous year.
[2]Includes one female present prior to the initiation of current tag studies.

Table 8.5. A comparison of first year tag returns for three cohorts: 1997/98 – 1999/00. Values in parentheses are percents.

Cohort	Total Tags Placed	Tag Returns in Year 1 (%) Total	Males	Females
1997/98	500	22 (4.4)	10 (2.0)	12 (2.4)
1998/99	500	6 (1.2)	5 (2.0)	1 (0.4)
1999/00	500	26 (5.2)	15 (3.0)	11 (2.2)

Table 8.6. Tag re-sights and minimum percent survival for two cohorts, 1997/98 and 1998/99 using the first two years of sighting data for each cohort.

	1997/98:			**1998/99:**		
	TOTAL	**Males**	**Females**	**TOTAL**	**Males**	**Females**
Sightings:						
Sighted in Year 1:	22	10	12	6	5	1
Additional Tags Sighted in Year 2:	32	10	20	13	7	6
Minimum survival in year 1:	54[1]	20	32	19	12	7
Tag loss:						
Unknown tag status:	3	1	2	2	2	0
Both tags present:	29	13	14	12	6	6
Missing 1 tag:	22	6	16	5	2	3
Probability of missing one tag:	0.43	0.32	0.53	0.29	0.25	0.33
Probability of missing both tags[2]:	0.19	0.10	0.28	0.09	0.06	0.11
Survival estimates:						
Minimum % Survival 1st year:	10.8	8.00	12.80	3.8	4.8	2.8
Adjusted minimum % Survival for year 1[3]:	**12.8**	8.80	16.44	**4.1**	5.1	3.1

[1]Includes two sightings of seals of unknown sex.
[2]Assumes tag loss is independent for right and left tags.
[3]Adjusted for double tag loss.

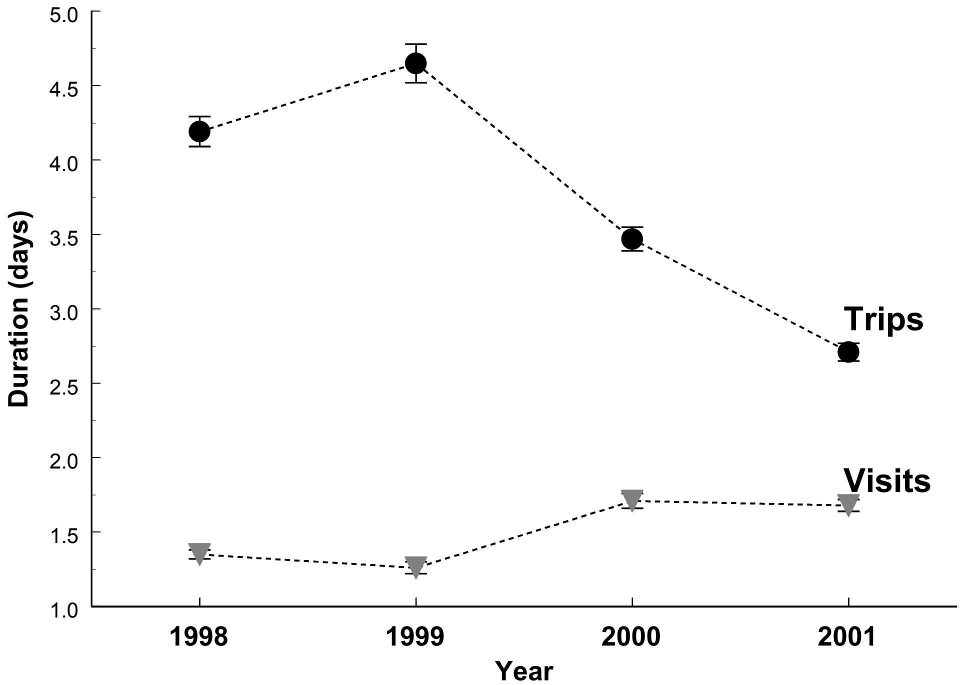

Figure 8.1. Antarctic fur seal trip and visit durations for females rearing pups at Cape Shirreff, Livingston Island. Data plotted are for the first six trips to sea and the first six non-perinatal visits following parturition for the last three years (**1997/98:** $N_{Females} = 30$, $N_{Trips} = 180$; **1998/99:** $N_{Females} = 31$, $N_{Trips} = 186$; **1999/00:** $N_{Females} = 23$, $N_{Trips} = 138$; **2000/01:** $N_{Females} = 28$, $N_{Trips} = 168$). Sample sizes for visits are the same as trips.

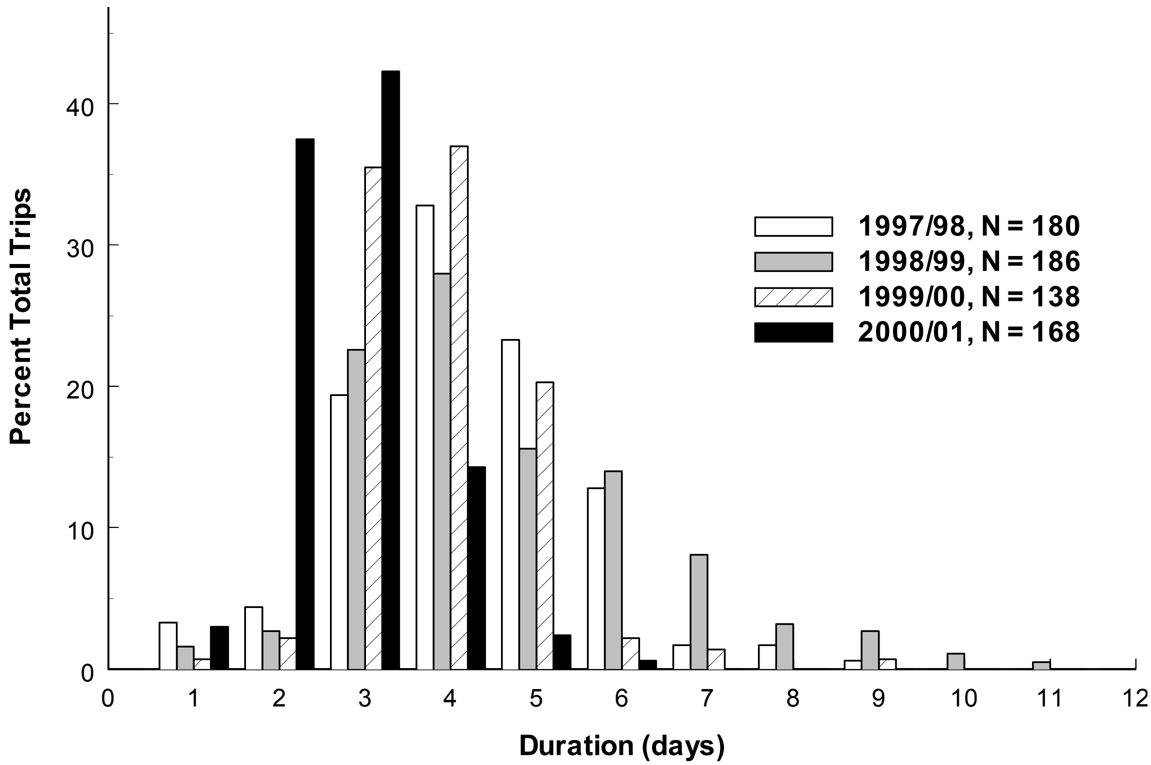

Figure 8.2. The distribution of Antarctic fur seal trip durations at Cape Shirreff, Livingston Island for four years (1997/98-2000/01).

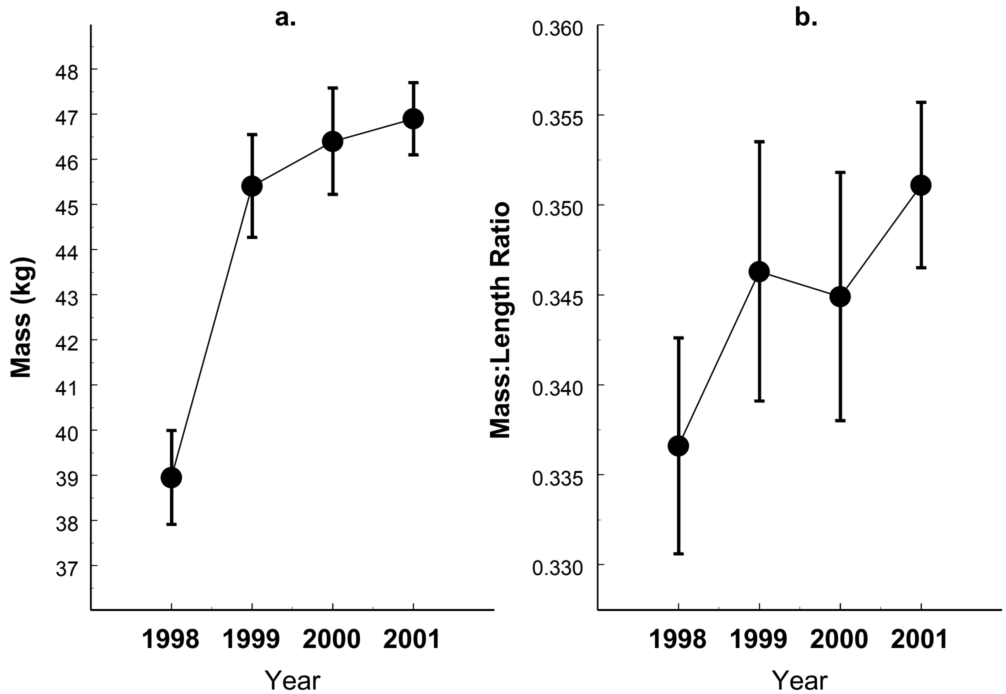

Figure 8.3. The mean mass (**a.**) and mass:length ratio (**b.**) for CCAMLR Attendance Study females for 1997/98 – 2000/01 (**1997/98:** N=31, **1998/99:** N=32, **1999/00:** N=23, **2000/01:** N=28).

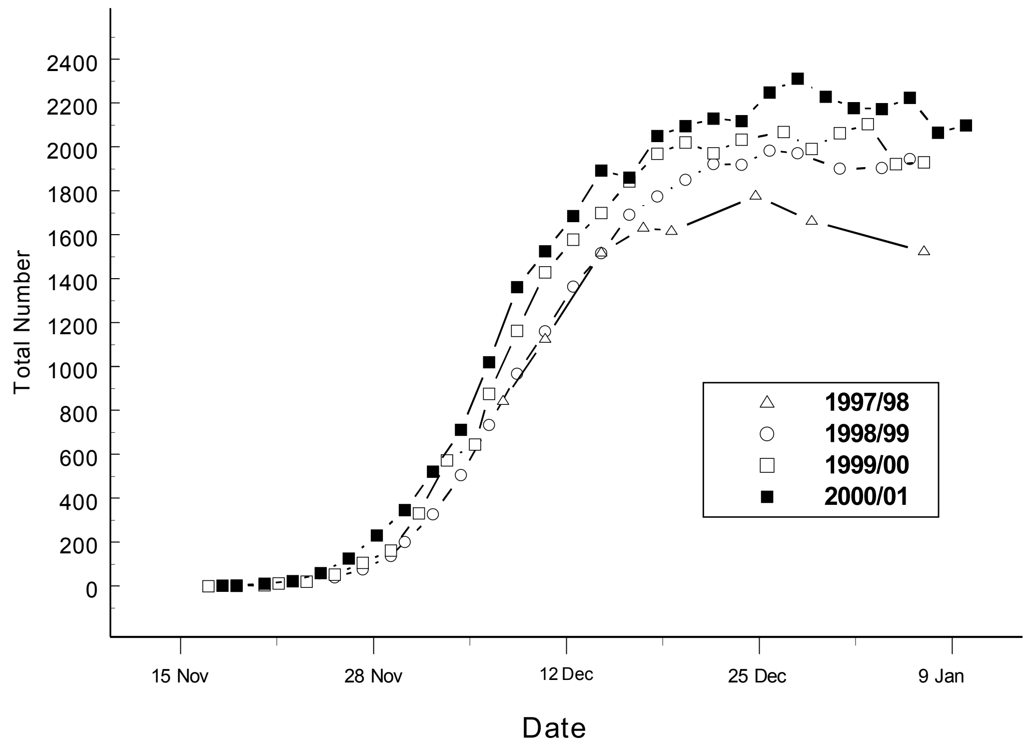

Figure 8.4. Antarctic fur seal pup production at US-AMLR study beaches, Cape Shirreff, Livingston Island, 1997/98-2000/01.

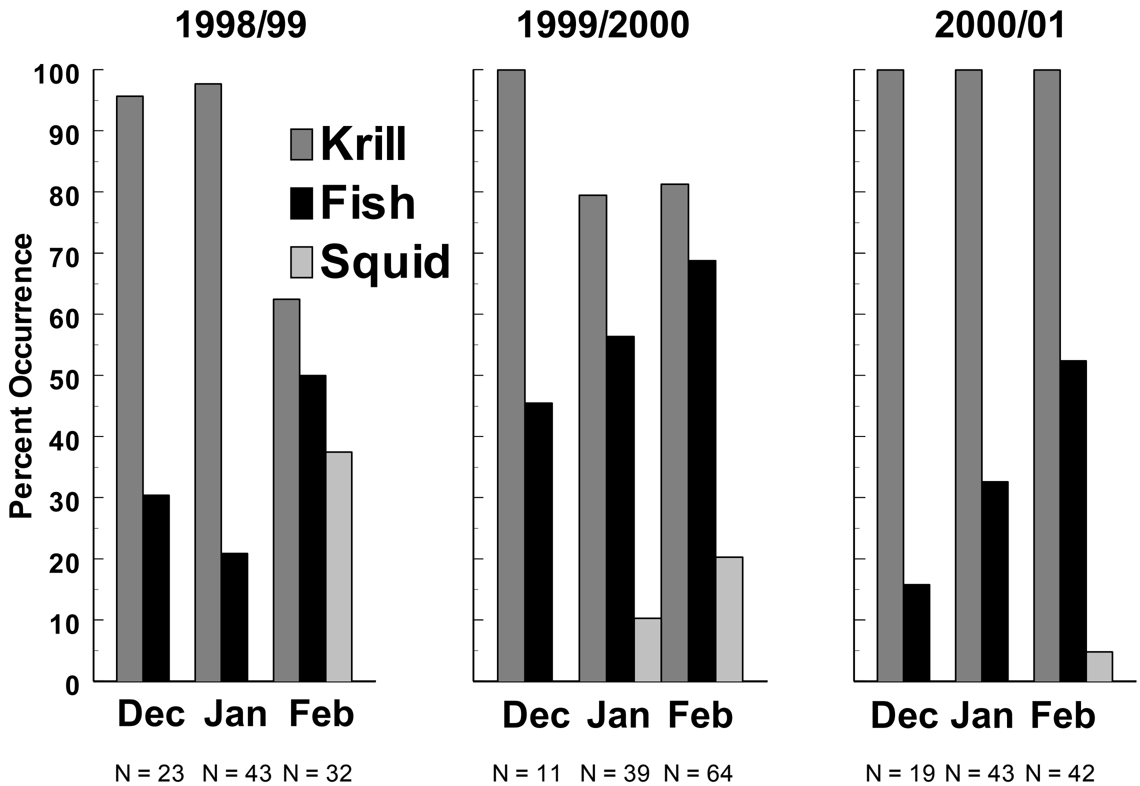

Figure 8.5. The percent occurrence of primary prey types (krill, fish, and squid) from December through February for Antarctic fur seal scats and enemas collected from female suckling areas at Cape Shirreff, Livingston Island for 1998/99 through 2000/01.

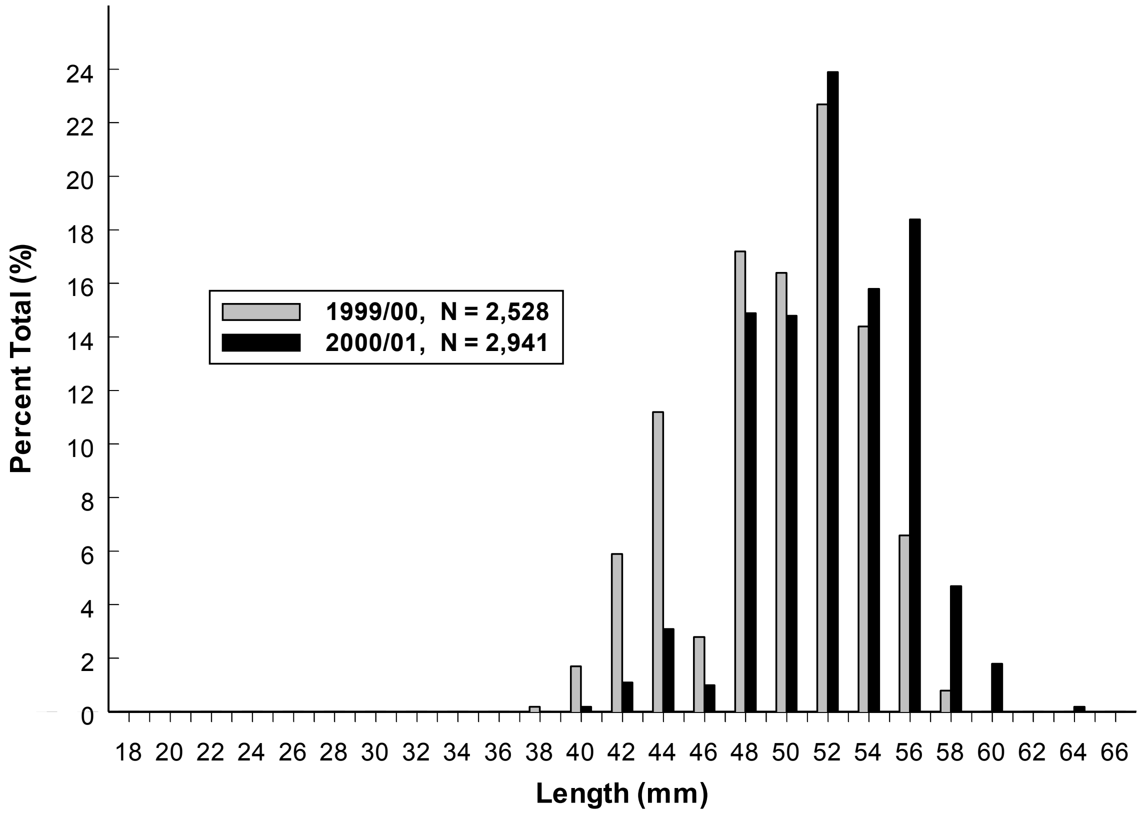

Figure 8.6. The size distribution of krill in Antarctic fur seal diet at Cape Shirreff, Livingston Island in 1999/2000 and 2000/01.

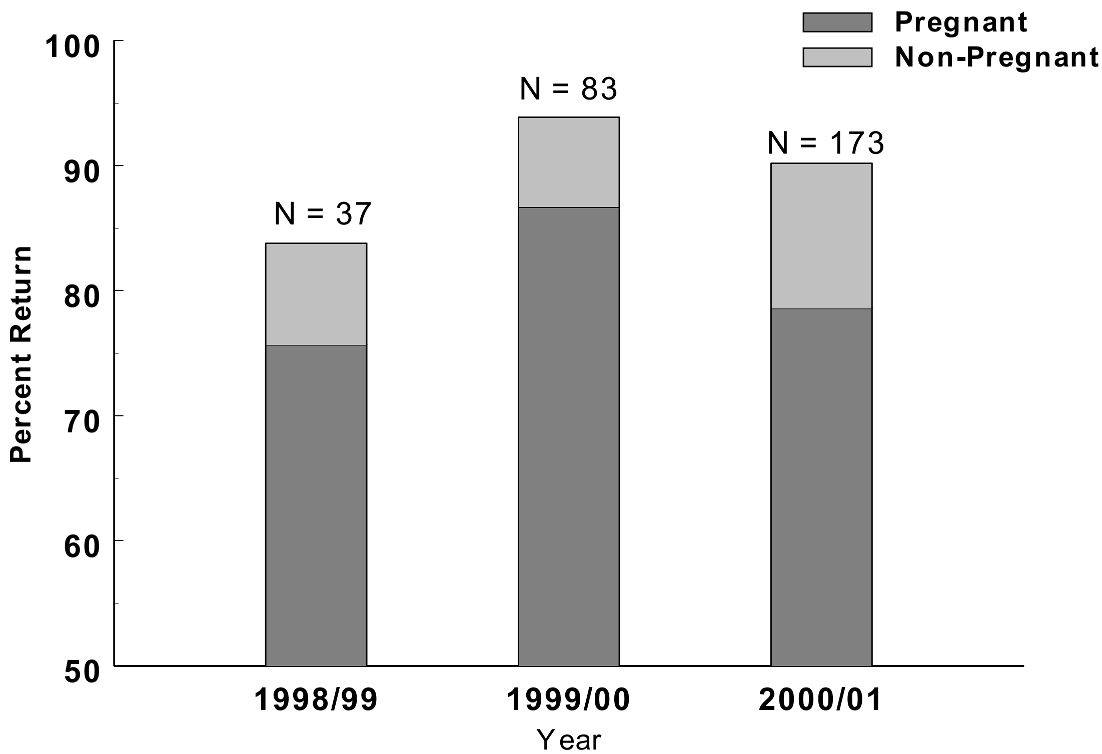

Figure 8.7. Adult female Antarctic fur seal tag returns for three years (1998/99-2000/01) at Cape Shirreff, Livingston Island.

Figure 8.8. The effect of extracting a single post-canine tooth on the following year's tag returns and natality for adult female fur seals at Cape Shirreff, Livingston Island.

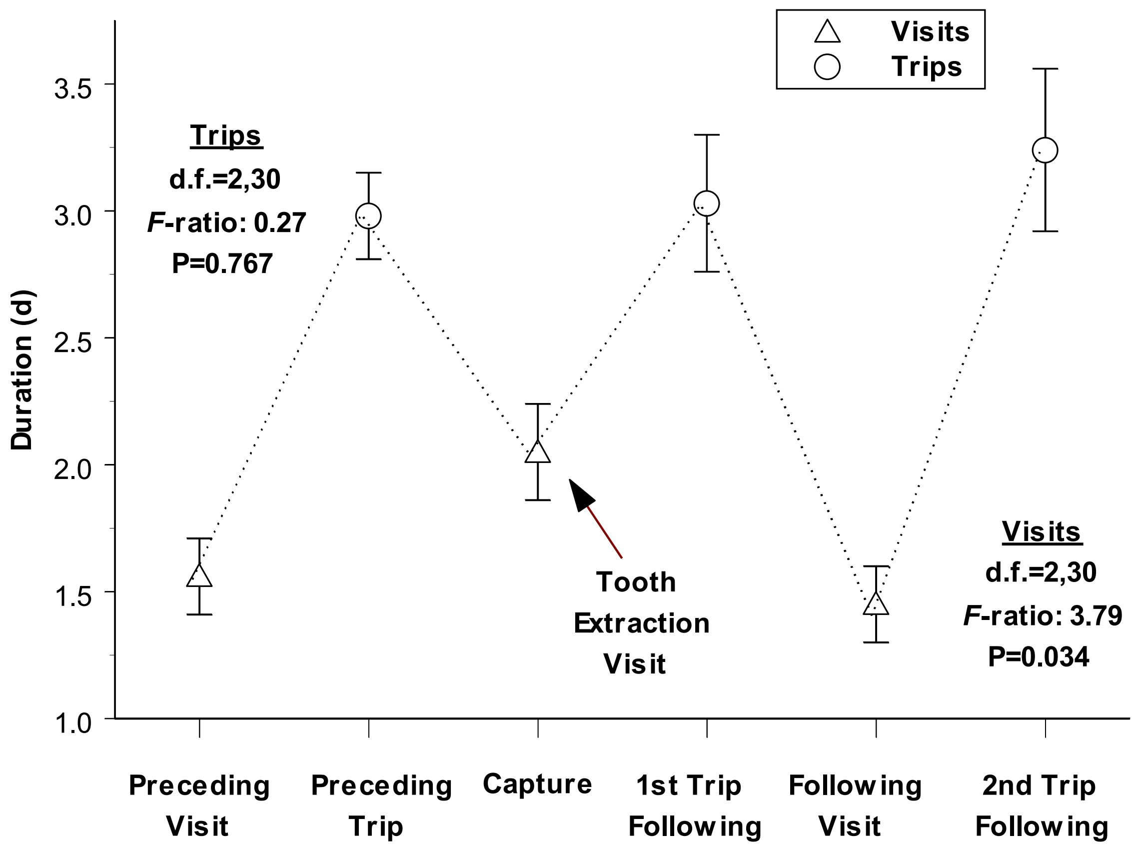

Figure 8.9. The effect of capture and extraction of a single post-canine tooth on female visit and trip duration. Data are for 11 females that were captured from 17-29 January 2001.